PATENT
Attorney Docket No.: 62888.00001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		Examiner:	GOLUB, MARCIA A
	Mali Gong et al.		
Serial No.:	10/719,072	Art Unit:	2828
Filed:	November 21, 2003		
Title:	Corner-Pumping Method and Gain Module for High Power Laser Slab (as amended)		

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT AND RESPONSE

Sir:

In response to the Office Action dated June 16, 2006, please amend the above-identified application as follows:

In the title:

Corner-Pumping Method and Gain Module for ~~Solid-State~~ High Power Slab Laser

In the abstract:

[[A]] Corner [[corner]]-pumping method and gain module for high power slab laser ~~and a solid-state laser gain module~~ are disclosed. In one embodiment, said method comprises directing a pump light from one or more pump light sources each consisting of a high power diode array and its coupling system into a laser slab through prior cut slab corners of said laser slab without restriction to the incident angle or the polarization state of the pump light, wherein said laser slab includes an undoped circumambient portion and one or more doped central portions; propagating [[the]]said pump light within the laser slab by total internal reflection (TIR), wherein said pump light firstly pass said undoped circumambient portion, secondly pass said doped central portion, thirdly pass said undoped circumambient portion again, and fourthly take inner reflection at the surface of said undoped circumambient portion, and by repeating these steps, achieve multi-pass absorption; and substantially absorbing the pump light during propagating. In another embodiment, said gain module comprises a laser slab formed by [[a]] solid state laser material, said laser slab including an undoped circumambient portion and one or more doped central portions and prior cut slab corners with corner faces; and [[a]] one or more pump source providing a pump light; wherein said pump light is directed into said laser slab through said slab corners of said laser slab, propagated within said laser slab ~~by total internal reflection (TIR),~~ and substantially absorbed during propagation; and wherein said laser slab outputs an amplified laser beam.

In the Claims:

1. (Currently Amended) A corner-pumping method for high power slab laser comprising:

directing a pump light from one or more pump light sources each consisting of a high power diode array and its coupling system into a laser slab through prior cut slab corner[[s]] faces of said laser slab without restriction to the incident angle or the polarization state of the pump light, wherein said laser slab includes an undoped circumambient portion and one or more doped central portions;

propagating ~~the~~ said pump light within ~~the~~ said laser slab ~~by total internal reflection (TIR)~~, wherein said pump light firstly pass said undoped circumambient portion, secondly pass said doped central portion, thirdly pass said undoped circumambient portion again, and fourthly take inner reflection at the surface of said undoped circumambient portion, and by repeating these steps, achieve multi-pass absorption; and

substantially absorbing the pump light during propagating~~,~~

~~wherein said laser slab includes a circumambient portion and a central portion, said circumambient portion including an un-doped host area, said center portion including one or more doped host areas~~.

2. (Original) The method as recited in claim 1, wherein corner faces of said laser slab are coated for high transmission for the wavelength of the pump light, and lateral faces of said slab are coated for high reflection for the wavelength of the pump light.

3. (Currently Amended) The method as recited in claim 1, wherein a laser light propagates inside the laser slab ~~between two TIR~~ faces in a zigzag optical path.

4. (Currently Amended) The method as recited in claim 1, wherein the step of absorbing achieves a high absorption efficiency through ~~total internal reflection (TIR)~~ multi-pass absorption of pump light inside said laser slab.

5. (Canceled).

6. (Currently Amended) A ~~solid-state~~ corner-pumped laser gain module for high power slab laser comprising:

a laser slab [~~formed by a solid-state laser material, said laser slab including an input receiving an input beam, an output outputting an output beam and slab corners with corner faces~~ including undoped circumambient portion, one or more doped central portions and corner faces; and

[[a]]one or more pump source providing a pump light, each pump source consisting of a high power diode array and its coupling system;

wherein said pump light ~~is directed into said laser slab through said slab corners of said laser slab, propagated within said laser slab by total internal reflection (TIR), and substantially absorbed during propagation~~ from said one or more pump sources directly incident into said laser slab through prior cut slab corner faces of said laser slab without restriction to the incident angle or the polarization state of the pump light, firstly pass said undoped circumambient portion, secondly pass said doped central portion, thirdly pass said undoped circumambient portion again,

and fourthly take inner reflection at the surface of said undoped circumambient portion, and by repeating these steps, achieve multi-pass absorption, and substantially absorbed by the said doped central portion during propagation; and

wherein said laser slab outputs an amplified laser beam~~;~~

~~wherein said laser slab includes a circumambient portion and a central portion, said circumambient portion including an un-doped host area, said center portion including one or more doped host areas~~.

7. (Original) The laser gain module as recited in claim 6, wherein the number of said corner faces is four.

8. (Canceled).

9. (Previously Presented) The laser gain module as recited in claim 6, wherein a cross section of said central portion is square or circular.

10. (Original) The laser gain module as recited in claim 6, wherein said corner faces of said laser slab are coated for high transmission for the wavelength of the pump light, and lateral faces of said slab are coated for high reflection for the wavelength of the pump light.

11. (Currently Amended) The laser gain module as recited in claim 6, wherein the input beam and the output beam are located at ~~one~~ a same side of said laser slab, said input beam and said output beam forming an angle with each other.

12. (Currently Amended) The laser gain module as recited in claim 11, wherein two mirrors are placed at ~~another~~ a side of the said laser slab other than the side where the input and output beams are located, the two mirrors placed symmetrically with respect of said input beam and said output beam.

13. (Currently Amended) The laser gain module as recited in claim 6, wherein ~~said pump source includes a diode array and a coupling system,~~ said coupling system including two cylindrical lenses and a lens duct, said two cylindrical lenses being placed between the diode array and the lens duct, generatrices of said two cylindrical lenses are orthogonal to each other and are parallel to fast axis and slow axis of said diode array, respectively.

14. (Currently Amended) The laser gain module as recited in claim 6, wherein ~~said pump source includes a diode array and a coupling system,~~ said coupling system being a fiber bundle.

15. – 18. (Canceled).

REMARKS

In the Office Action, claims 1 7 and 9 – 18 were pending when last examined and were rejected under 35 U.S.C. 102(b) as being anticipated by Zhang (US pub. 20020105997).

The applicants hold that as compared with Zhang's patent, the claims, as amended, of the present invention possess novelty and inventiveness based on the following reasons:

1. The purposes of Zhang's patent and present invention are different.

In particularly, the purpose of Zhang's patent is to effectively solve thermal distortion problems and obtain TEM00-mode operations for diode-pumped solid-state lasers, in relatively low power region. While in present invention, the purpose is to obtain high absorption efficiency by multi-pass absorption in **high power** diode-pumped solid-state lasers. With different purposes, these two inventions emphasize different aspects of solid-state laser design.

2. The technical solutions of Zhang's patent and present invention are different.

(1) In Zhang's patent (see Fig. 5A-5B, 6A-6B, etc), the pump light is coupled to the laser slab 2 by optical duct 17 through a standard prism 18. Here, the optical duct 17 is used to guide pump light to the laser slab 2 by total internal reflection (TIR) at the side surface of optical duct. **Without this optical duct, the pump light cannot be guided to the laser slab and therefore cannot be absorbed**. While in present invention, **the pump light is directly guided to the laser slab corner surface, and absorbed by the central doped portion**. The undoped circumambient portion does not serve as an "optical duct" to guide pump light. Further, the incident surface of the pump light is firstly the prism surface and secondly side surface of the optical duct. To decrease coupling loss, the prism and the optical duct should be tightly touched by some means of optical bonding or others. This would bring problem under high power pumping condition. The interface between prism and optical duct is intended to break down while pump power is high. While in present invention, **the pump light is directly coupled to the laser slab corner surface without any optical bonding interface between coupling system and laser slab**. This kind of coupling method could endure higher pump power level better than that in Zhang's patent. In one particular case in Zhang's patent, i.e. in Fig. 7A, an alternative approach to

inputting pump light is shown. In this approach, standard prism 18 is not used but the optical duct 17 is cut on a corner to form a "corner surface", and the pump light is directed to said "corner surface" of said optical duct. In this case, **the incident angle for this pump light is fixed to Brewster angle in order to decrease coupling loss** (see Fig.7A as below, I_B refers to Brewster angle). This requires that the input pump light should be linear polarized with a specific incident angle, which additionally requires a collimated laser diode with nearly parallel output. While in present invention, **the pump light is directly guided to the prior cut corner surface of the laser slab without restriction to the incident angle or the polarization state of the pump light**. The pump light could be of any polarization state and the incident angle could vary in a relatively large range, i.e., the pump light could be of relatively large divergence in both directions (see Fig. 1 as below). The pump light firstly passes said undoped circumambient portion, secondly passes said doped central portion, thirdly passes said undoped circumambient portion again, and fourthly takes inner reflection at the surface of said undoped circumambient portion, and by repeating these steps, achieve multi-pass absorption.

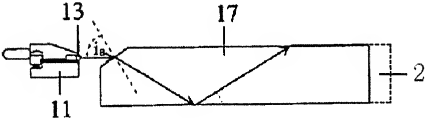

Fig. 7 A

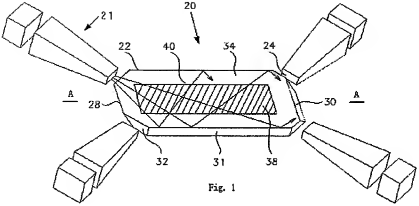

Fig. 1

(2) In Zhang's patent (Fig. 4A-4D), instead of optical duct 17, the pump light from linear array laser diode bar is directly coupled into a stripe entrance 5 of a noncircular-profile reflector 14 with or without collimating lens. While in present invention, the pump light from laser diode array (linear or two-dimensional) is coupled to the laser slab corner surface **by a coupling system**. Here, the whole corner surface (not a stripe entrance) is used to accept pump light, which increases the available input pump power.

(3) In Zhang's patent, the laser slab is sandwiched in between two optical ducts from both sides (see Fig. 5A-5B, 6A-6B, etc.) or an optical duct and a heat sink (see Fig. 14A-14D). In this case, the pump light firstly travels through the optical duct 17 (undoped YAG, without absorption) and secondly the laser slab 2 (doped YAG, with absorption). The pump absorption only takes place in the doped laser slab, and mostly from the thickness direction (see Fig. 5A-5B, 6A-6B, 14A-14D, etc.), which means that the absorption length is relatively short, even if multi-pass absorption occurs. While in present invention, **the laser slab includes an undoped circumambient portion and one or more doped central portions. In this case, the pump light will pass the doped portion after nearly each inner reflection at the surface of undoped portion**. The pump absorption takes place after nearly each inner reflection, and mostly from the length direction, which means that the absorption length is much longer than that in Zhang's patent. Achieving long absorption length (and therefore high absorption efficiency) is the most essential purpose of this kind of "corner-pumping" technique, especially

for those quasi-three-level lasing materials with relatively small absorption coefficient. From this point of view, the applicants believe that the present invention is of superior to Zhang's patent.

To sum up, the technical features (a)"**high power**"; (b)"pump light sources each consisting of a high power diode array and **its coupling system**"; (c) "**without restriction to the incident angle or the polarization state of the pump light** "; (d) "**said laser slab includes an undoped circumambient portion and one or more doped central portions**"; and (e) "**said pump light firstly pass said undoped circumambient portion, secondly pass said doped central portion, thirdly pass said undoped circumambient portion again, and fourthly take inner reflection at the surface of said undoped circumambient portion, and by repeating these steps, achieve multi-pass absorption**" in amended independent claims 1 and 6 of the present invention are not disclosed by Zhang's patent. Therefore, as compared with Zhang's patent, amended independent claims 1 and 6 of present invention should possess novelty and inventiveness. Further each of dependent claims also possess novelty and inventiveness, at least by virtue of their dependency.

In conclusion, Applicants respectfully submit that all claims are patentable and request a Notice of Allowance be issued. If the Examiner has any questions or needs any additional information, the Examiner is invited to contact the undersigned.

Respectfully submitted,
Mali Gong et al.

Dated: 9/5/06

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